May 21st, 5:00 PM - 5:20 PM

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MODELLING THE POLARIZATION, MIGRATION AND NEUROMAST DEPOSITION IN THE ZEBRAFISH POSTERIOR LATERAL LINE SYSTEM

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Abstract

Collective cell migration plays an important role in a variety of biological systems, such as embryonic development, wound healing and cancer invasion. Here we study a specific example in the zebrafish embryo, where a group of about 100 cells called the posterior lateral line primordium (or PLLP), destined to form sensory structures, migrates from head to tail. Using a 3D deformable cell-based simulation, coupled to reaction-diffusion PDEs for chemical concentrations, we model and simulate the polarization, migration, and neuromast deposition in the PLLP. The model combines realistic cell-cell adhesion and interaction forces, chemotaxis up a gradient of the chemokine SDF-1, and up an FGF ligand gradient to describe the emergence of tissue polarity, as well as cell-cluster shape and speed of collective cell migration. We base the chemical signalling model on receptor-ligand kinetics and mutually inhibitory FGF-Wnt signalling. Our signalling submodel allows predictions to be made for the position of the front-rear boundary in the PLLP, as a function of aggregate parameters such as steady-state receptor expression levels and IC_{50} parameters for the mutually-inhibitory effect. Our 3D model allows an investigation of the role of cell division, chemotaxis, adhesion and other parameters on the shape of the PLLP and demonstrates reasonable behaviour of control as well as mutant phenotypes.